A NEW SPECIES OF

CEPHALODISCUS

(C. GILCHRISTI)

FROM THE

CAPE SEAS.

BY

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The material here described consists of 19 specimens (*i.e.*, pieces of colony) obtained on nine different occasions in the Cape Seas, mostly at depths of about 30 fathoms, although some of them were dredged from greater depths. The specimens were dredged by Dr. J. D. F. Gilchrist, and sent to Professor E. Ray Lankester, Director of the Natural History Museum, London, to whom I offer my thanks for his kindness in allowing me to examine and describe them. By way of recognition of the service which Dr. Gilchrist has rendered to science by his successful efforts to obtain this *Cephalodiscus* in quantity after his interest had been aroused by the dredging of a small piece of it, I name the species *C. gilchristi.*

In the following list of the material I distinguish the various specimens by the numbers appended to them by Dr. Gilchrist, or his assistant, at the time of dredging. The finest specimen is that numbered 18551, and of this a photograph of the natural size is reproduced in plate 1 ; the other pieces are all small, rarely consisting of more than one branch each. Dr. Gilchrist has been at great pains to harden these smaller pieces of material in various fixing fluids of acknowledged efficiency, so that the polypides might be in good condition for histological investigation.

Specimen 1945 ; January 10th, 1900 ; Cape St. Blaize, N. by W., 3 miles ; 30 fathoms ; bottom, mud ; fixed in 3 per cent. formalin, and transferred to 70 per cent. alcohol.

Specimen 10265; October 11th, 1900: Knysna Heads, N.E. $\frac{3}{4}$ E., $12\frac{1}{2}$ miles; 47 fathoms; bottom, rock: fixed in 3 per cent. formalin, and transferred to 70 per cent. alcohol.

Specimen 13203: July 30th, 1901; near East London, Cove Rock, N.W. $\frac{3}{4}$ W., $13\frac{1}{2}$ miles; 80-130 fathoms: bottom, coral and rock; fixed in 3 per cent. formalin, and transferred to 70 per cent. alcohol.

Specimen 14273; February 19th, 1902; Cape St. Francis, N.E. by E. $\frac{1}{2}$ E. 36 miles: 70 fathoms; bottom, rock; fixed in 3 per cent. formalin, and transferred to 70 per cent. alcohol.

Specimen 18551: September 13th, 1904; Cape St. Blaize, N.W. by W., 5 miles; 31 fathoms; bottom, mud: fixed in $7\frac{1}{2}$ per cent. formalin, and transferred to 70 per cent. alcohol.

Specimen 18551A; selected branches of the last in which the polypides were abundant; fixed in osmic acid 1 per cent. solution for 5–10 minutes, washed for several hours in distilled water, and transferred through grades of alcohol up to 90 per cent.

Specimen 18612A; October 18th, 1904; Cape St. Blaize. W. by N., 5 miles; 29 fathoms; bottom, fine sand; procured by large trawl, and hauled up off Cape St. Blaize, N.N.W., 8 miles; 38 fathoms; bottom, fine sand; fixed in glacial acetic acid for 15 minutes; washed in 50 per cent. alcohol for 8 hours, and transferred to 70 per cent. alcohol.

Specimen 18612B; material as above; fixed in absolute alcohol, 24 hours, and transferred to 70 per cent. alcohol.

Specimen 18612C; material as above; fixed in fluid as follows: corrosive sublimate 7 grammes, distilled water 100 cc., acetic acid 1 cc.; after 15 minutes, washed in 70 per cent. alcohol, and transferred to more 70 per cent. alcohol.

Specimen 18633D; October 20th, 1904; Cape St. Blaize, N., 5 miles; 34 fathoms; bottom, mud; procured by large trawl, and hauled up off Cape St. Blaize, N.E. $\frac{1}{2}$ E., 6 miles; 30 fathoms; bottom, mud; fixed in equal parts of sea water and Flemming's solution (5 per cent. acetic acid added to osmic acid and chromic acid solutions at time of using): after 24 hours, removed to fresh water, frequently changed, for 24 hours; then 30 per cent. alcohol, 6 hours; 50 per cent. alcohol, 9 hours; and finally 70 per cent. alcohol.

Specimen 18633E; material as above; fixed in Perenyi's fluid, 6 hours; washed in 70 per cent. alcohol, 24 hours; transferred to 70 per cent. alcohol.

Specimen 18633F; material as above; fixed in glacial acetic acid, 20 minutes; washed in 50 per cent. alcohol, and transferred to 70 per cent. alcohol.

Specimen 18633G; material as above; fixed in corrosive sublimate and acetic acid solution (for formula see specimen 18612C), 24 hours; 30 per cent. alcohol, 3 hours; 50 per cent. alcohol, 24 hours; finally 70 per cent. alcohol.

Specimen 18633H; material as above; fixed in absolute alcohol, 24 hours, and transferred to 70 per cent. alcohol.

Specimen 18655I; October 26th, 1904; Cape St. Blaize, N.W., 6 miles; 35 fathoms; bottom, mud; procured by large trawl, and hauled up off Cape St. Blaize, N.N.W., 6 miles; 35 fathoms; bottom, mud; fixed in freshly-made Perenyi's fluid, 6 hours; washed in 70 per cent. alcohol, 24 hours, and transferred to 70 per cent. alcohol.

Specimen 18655J; material as above; fixed in strong alcohol (absolute alcohol which had been previously used for fixing specimens), 24 hours, and transferred to 70 per cent. alcohol.

Specimen 18655K; material as above; fixed in Flemming's fluid which had been previously used, 24 hours; washed in several changes of water, 24 hours; 30 per cent. alcohol, 6 hours; 50 per cent. alcohol, 6 hours, and transferred finally to 70 per cent. alcohol.

Specimen 18655L; material as above; fixed in freshly-made Flemming's fluid (see notes to specimen 18633D), 24 hours; several changes of water, 24 hours; 30 per cent. alcohol, 6 hours; 50 per cent. alcohol, 6 hours; finally into 70 per cent. alcohol.

Specimen 18663; October 28th, 1904; Cape St. Blaize, W.N.W., 5 miles; 31 fathoms; bottom, mud; procured by large trawl, and hauled up off Cape St. Blaize, N.W. by N., 5½ miles; fixed in absolute alcohol 24 hours; and transferred to 70 per cent. alcohol.

Tubarium.—The finest piece of *Cephalodiscus gilchristi* sent to the Natural History Museum, London, is that of which a photographic reproduction is given in plate 1. It is the specimen marked 18551 in the preceding list of material. It measures roughly 190 mm. by 110 mm., and is of a reddish brown tinge. This piece was sent in a 7½ per cent. solution of formalin in a tinned iron box, and the fluid on arrival was turbid and red, owing to the rusting of the iron. The rusty tinge of the specimen has diminished since it was placed in alcohol, but it has not disappeared. The colour of other specimens fixed in formalin and transferred to alcohol, and of those fixed in alcohol, is pale brown.

Specimen 18551 consists of an attached base and branches. The base, shown in the left-hand lower corner of the plate, measures 60 by 45 mm. across. There is no indication of the object to which the colony was attached; the base has come away clean. The base is massive, of uniform character, without spines and without ostia. The branching stems that arise from the base are roughly circular in section ; the parts nearer the base are thicker than those more remote. The thicker branches are about 10 mm. across (not including the spines) ; they have shorter spines than the more terminal branches, and fewer ostia : the ostia are more abundant on one side than on the other. In the more terminal branches the width varies from 5 to 8 mm., and the apertures are more uniformly distributed. The distance from one branch to the next is about 30 mm., but it may be as much as 55 mm., or as little as 17 mm.

The cross-bars joining up adjacent branches of the colony which M'Intosh noticed in *Cephalodiscus dodecalophus* ("Challenger" Reports, *Cephalodiscus*, 1887) are here a marked feature of the tubarium. One such bar is seen towards the left-hand upper corner of plate 1, and a thicker one at some distance above the centre of the plate. They are solid, and have few or no apertures : they measure from 4 to 8 mm. across. They act either as tie-rods to prevent the several branches of the colony from breaking apart, or else as bridges for the polypides to pass along from branch to branch. Although, on the whole, the polypides reside in the cavities of the tubarium, yet one must admit the existence of migrating polypides, otherwise it is impossible to explain the increase in the length of the branches of the tubarium, the production of lateral branches, and the formation of the cross-bars and the spine-like processes of the tubarium. Possibly the wandering polypides are in all cases young ones which have only recently severed their connection with the stolon of their parent, and have left the parental home and are in search of a suitable position in the colony in which to settle down and secrete protecting tubes of their own.

When the cross-bars are at all thick, they include embedded in their midst one or more of the spines which happened to occur in the neighbourhood. In the transverse section shown in fig. 8, plate 3, it is evident, from the way in which the strata of test are disposed, that the spine *a* is the organic axis, and remained for some time the only embedded spine of the cross-bar. Later, however, the spines *b* and *c* became entangled and buried, and still more recently the spine *d*.

Although in the case of specimen 18551 Dr. Gilchrist states that a great many of the polypides fell out and collected at the bottom of the vessel when the colony was plunged into formalin, a great many still remain in the tubes of the tubarium, and entangled among the spine-like processes (see plate 1).

The spines of the tubarium are numerous, fairly flexible, slender, straight, occasionally forked. They measure ·3 to ·4 mm. in thickness, and they taper but slightly; they frequently attain a length of 13 mm., although the majority are shorter, and measure 9 or 10 mm. beyond the surface of the tubarium. The spines are darker in tint than the general test, and can be traced into the latter for a considerable distance. The spines are solid; the superficial layer has a deeper tint than the central part, so that on a casual examination the spines appear hollow. Critical inspection, however, shows that the spine-axis has been developed intermittently by successive additions to its extremity, the increments being all of the same shape, and approximately of the same size. The successive apices are, with the exception of the first few at the embedded base of the spine, all of the same width, and this accounts for the width of the spine remaining the same all the way along (see figs. 9–11, plate 3).

The ostia or apertures of the tubarium are numerous, fairly closely set and uniformly scattered over the lateral and terminal surfaces of all the branches except the basal ones (fig. 1, plate 2). They are oval in shape and measure 1·2 or 1·3 mm. by 1 mm. across. In fig. 7, plate 3, is shown an end view of a branch, the view that one would obtain when looking in the direction of the axis of the branch. The pear-shaped areas are the ostia, the small circles are the stumps of spines, cut short in order that their relations to the ostia may be studied. At *a* and *b* it will be seen that there is one spine between two ostia, but in the other cases each tube has a spine of its own.

Except in the case of terminal groups, such as that shown in fig. 7, plate 3, the spines are not at first sight definitely related to the ostia; as a rule each ostium has one, perhaps two, or even three spines arising from its margin, but some of the spines project form the surface of the tubarium between the ostia. The spines that arise from the margin of the ostium may arise from any part of that margin, *i.e.*, not necessarily towards the axis of the branch, nor on the peripheral side nor laterally as regards the ostium. Sometimes two tubes project together from the general surface of the tubarium as a double peristome, and these may have a single spine between them, or may have two, or three spines. The number of spines on a branch is probably equal to the number of ostia, but one can only in certain cases recognise a definite relation between tubes and spines.

The tubes occupied by the polypides are all blind at their deep ends, and each is occupied by one polypide and its buds, so that the species *Cephalodiscus gilchristi* comes within the sub-genus *Idiothecia* (see Reports "Discovery", Expedition. *Cephalodiscus*, 1906. p. 7). The tubes are 1 to 1.2 mm. wide. rarely 1.4 mm.. and they vary in length from 2.5 to 5 mm. They are of uniform diameter, but in some cases the opening or ostium is a little wider than the tube itself: the blind end is usually blunt (see plate 3, figs. 9–11). The inner or blind ends of the tubes curl in and out among one another, but the more superficial parts are straighter (figs. 2 and 3, plate 2).

The shortest tubes are to be found at the extremities of the branches (fig. 10, plate 3). Here the paler. softer, and presumably newer test that agglomerates the tubes and spines together is less abundant than elsewhere. It would seem that the young polypides of the colony crawl over the surface of the tubarium, and, on coming to rest at the end of a branch. first secrete short tubes and spines, and subsequently secrete the softer test which fills in the intervals between the projecting parts of the tubes (peristomes) and spines. The tubes are lengthened by additions at their mouths or ostia until they attain their maximum length of 5 mm., and soft test is deposited around them *pari passu* so as to envelop them up to the mouths, and to cover in more and more of the basal parts of the spines. This may explain why the spines are shorter towards the rooted end of the tubarium than near the distal ends: they are more submerged in the common test.

It not infrequently happens that a spine begun in relation with one tube becomes secondarily related to another and younger tube, as though a settling polypide, finding itself in the vicinity of a projecting spine, builds up its tube against it, and dispenses with the formation of a spine of its own. The relations of spines to tubes are best studied by reference to the ends of branches of the tubarium, and the following interpretation of three particular cases may serve to render the relations clearer than a generalised statement would.

In fig. 9. plate 3, is shown a group of four tubes and five spines cut from the end of a branch. The cut surface is represented by the irregular line at the bottom of the figure. The oldest spine here appears to be that marked *a*; it is darker in colour than the others; it extends all the way through the group of tubes under consideration. and in all probability it was not originated by any of the polypides occupying these tubes although the more terminal parts of the spine may have been put on by one or more of them. The tube which runs alongside the spine *a* is more remote from the observer than the spine itself, and has its aperture (*b*) facing away. The polypide which secreted and inhabited this tube commenced to construct it against the side of the spine *a*, and only comparatively recently produced a spine of its own (*e*). This spine has its origin against the side of the spine *a*, and is not an independent spine like *d*, for instance. It may here be mentioned that in all cases of "forked" spines there is a secondary spine applied to the side of a primary spine, as is the case in *Cephalodiscus hodgsoni* ("Discovery" Reports, 1906, p. 51. and plate 4, fig. 21).

The next tube in point of age is that marked *c* in fig. 9. Before the tube had attained more than half its present length, the polypide began to secrete a spine (*f*) by applying to the side of the tube first blunt mounds of test, and later steep deposits, of the shape of projectiles. Shortly after this another polypide settled by the side of tube *c* and spine *f*, and secreted a tube *g*, with a spine of its own (*d*) applied obliquely to the tube. Later still, another polypide settled down between the spines *f* and *a*, and secreted a tube (*h*), which is still in a comparatively early stage of construction, being short, and provided with a delicate projecting peristome. The polypide of tube *h* had, however, at the time when the specimen was dredged, already produced a spine *j*, which it began to secrete, not against the side of its tube as was the case with the polypides of tubes *c* and *g*, but against the side of the spine *f*, much as the polypide of tube *b* based its spine (*e*) against the side of the spine *a*. Thus it results that the four tubes are related to five spines; but one of the spines (*a*) was there in the first instance, and belonged primarily to an older tube, not shown in the figure, so that, as far as the group under consideration is concerned, there are as many spines as tubes.

Fig. 10 represents a group of five tubes which I interpret as follows. The shortness of the tubes implies that they are only recently formed, and the uniform character of the tubes that the five polypides settled almost at the same time. The spine *a* is probably a spine which was present before the advent of the five polypides in question, and three of the tubes are built against it, namely, *b*, *c* and *d*. The polypide of either *c* or *d*—possibly both—originated a new spine (*e*) against the side of the initial spine (*a*); the polypide of *b* seems to have appropriated to itself the spine *a*, perhaps in conjunction with the polypide of *c*; the polypides of tubes *f* and *g* have produced spines of their own (*h* and *j*), originating on the sides of their tubes.

Fig. 11 is interesting as an example of a branch-end with very little of the common test between the tubes. The consequence of the deficiency of this material makes the greater part of the tubes *a* and *b* to stand out from the general tubarium in the form of "peristomes," which circumstance shows that the characters of the peristomes are not in all cases of value for purposes of discrimination of species. In the present species, for instance, the tubes have either their ostia flush with the surface, or else they project a little from the surface. When, however, as in the piece of tubarium shown in fig. 11, the branch is growing so rapidly that the intervals between the tubes have not been filled up by common test, the tubes stand out boldly, and one would have to apply to such a piece the expression "peristomes long." This condition is exceptional, it is true, and would probably have been of short duration, but it indicates a difficulty in the satisfactory employment of the characters of the peristomes for distinguishing one species of *Cephalodiscus* from another.

In the piece of the colony shown in fig. 11 the spine *c* is, I take it, older than any of the three tubes shown, and was originated by a polypide whose tube does not appear in the piece selected, being set lower down the branch. The polypide occupying the tube *b* utilised this spine as a support for its tube, and originated from the side of the spine two spines of its own, *d* and *e*, the latter only in the initial stages of its formation. The polypide of tube *a* started a spine of its own (*f*), with its base against the side of the tube; and the polypide of the tube *g* produced two spines, one (*h*) set upon the side of the spine *c*, and the other (*i*) originating from the side of the tube.

Polypides.—The polypides of *Cephalodiscus gilchristi* do not present any remarkable peculiarities. The shield has a dark band around its front and side edges (fig. 4, plate 2, *b.s.*) which is peculiar to the species, but the red line (*r.l.*) and other features do not call for special comment. The shield is a very mobile organ judging from the numerous shapes in which it is found in the preserved material; and in buds especially is the posterior flap found either directed backward ventral to the mouth and parallel to the post-oral lamella (fig. 5, plate 2), or turned forward so as to be ventral to the main portion of the shield (fig. 6), or set at any angle intermediate between these two extremes.

The twelve plumes stand out rather distinctly in well-preserved polypides, and the ends of the individual plumes appear more pointed (fig. 4, plate 2, *pl.*) and less bunched than those of *C. dodecalophus* and *C. hodgsoni*, which they otherwise most nearly resemble. The body is swollen, the posterior end moderately pointed when seen from the ventral or dorsal aspect. The stomach causes a bulging of the two sides of the body (*ga.*); and in front of these projections there are in mature polypides a pair of others (*go.*), due to the gonads. The course of the rectum can usually be traced as a shallow mound along the dorsal surface of the body ; the anus is a large gaping slit at the anterior end of the visceral mass.

The gill-slit is situated postero-ventrally to the collar canal on each side of the body ; it is an oblique slit, sloping antero-ventrally as seen from the outside. It is only slightly larger than the collar pore, and is set at about the same transverse level of the body as the red line of the shield in cases where the posterior lobe of the shield is backwardly directed. The side of the post-oral lamella flaps over the external openings of the collar canal and gill-slit.

The stolon arises, on an average of cases, in the position in which it is shown in fig. 4, plate 2, but its point of origin is not constant, being sometimes nearer the mouth and sometimes nearer the hind end of the visceral mass than is shown in the figure. The stolon is longer than the whole body, plumes included, and may be as much as twice the length of the body if the polypide died with its stolon well extended. In the latter case the stolon is thin and free from superficial wrinkles. The number of buds usually found on the end of the stolon varies from two to five.

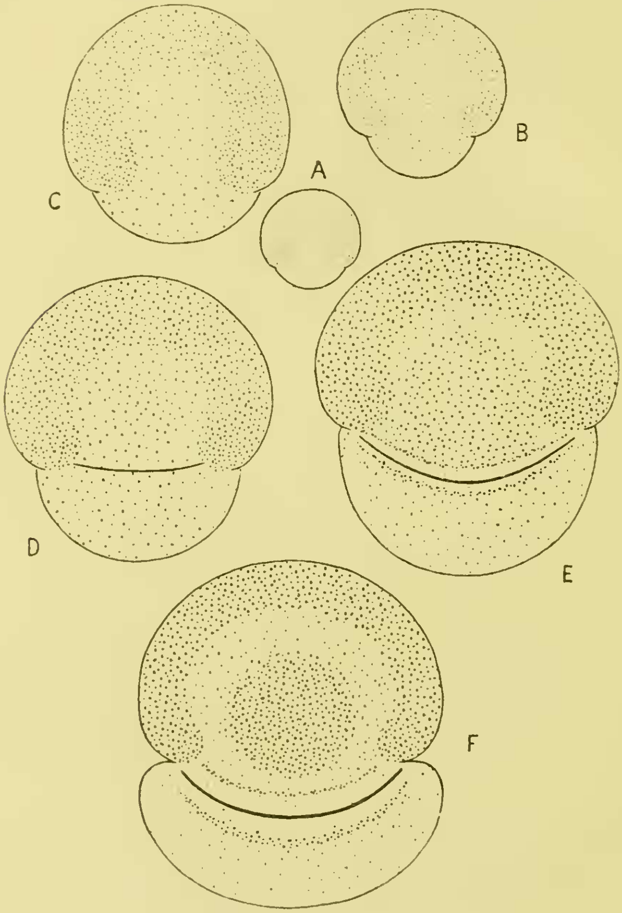
The average measurements of the polypides of *Cephalodiscus gilchristi* are as follows :—From end of visceral mass to anus, 1 mm. ; from end of visceral mass to front of buccal shield, 1·5 mm. ; from end of visceral mass to front of plumes, 1·8 mm.

Parasites.—Occurring very commonly in the stomach of *C. gilchristi* is a parasitic Copepod which almost fills the cavity and leaves very little room for food material. As a rule but one Copepod is found in the stomach ; in one case two were found, but neither of these was fully grown. Sometimes the stomach contains an adult female and four free eggs, or a female and four embryos, or four embryos of a later stage, without the mother. Mature females are common, but no adult male has been encountered ; possibly the adult male is free-living.

Dr. W. T. Calman has been good enough to examine this parasite for me, and he points our that it comes within the family Ascidicolidæ, Copepods parasitic mainly in the gut of Tunicates, and that it is most nearly allied to *Enterognathus*, a parasite described by Giesbrecht from the gut of *Comatula*. The parasite of *Cephalodiscus* is more degenerate than *Enterognathus*. The segmentation of the body is not clearly marked, the jaws are much reduced, the thoracic limbs are stout and stunted, and there are no projecting egg-sacs.

Buccal Shield.—The buccal shield of a well-expanded polypide of *C. gilchristi* (see text-fig. 1, F) measures about ·66 mm.

wide, and ·75 mm. high (*i.e.*, antero-posterior diameter). The proportions vary considerably, however, some shields being higher and narrower than the average, others being shorter and wider. The measurements above stated were arrived at by striking the average of the measurements of twenty-four well-expanded shields removed from the polypides and mounted in glycerine for microscopic examination.



TEXT-FIG. 1. Buccal shields of *Cephalodiscus gilchristi* in various stages of development. A,—the shield of a young bud. B,—shield of an older bud. C,—shield of an older bud than the last; no plume-rudiments were recognisable in this bud. D,—shield of an older bud than the last; the first two pairs of plumes of this bud were recognisable as hemispherical knobs; the red line of the shield has now appeared. E,—shield of a fairly old bud; the first three pairs of plumes of this bud were clavate and devoid of pinnules, the fourth pair were hemispherical knobs. F,—shield of an adult polypide. All the figures are drawn to the same scale, namely, × 60.

The posterior flap or lobe of the shield is thinner than the rest, but, on an average of cases, is as wide as the main part; there is a well-marked lateral notch between the posterior flap and the main portion of the shield. The pedicle or stalk of the shield is approximately central; its position is indicated in text-fig. 1, F, by the central dark area. The red line of the shield is usually curved, and is more or less parallel to the posterior edge of the hinder lobe; in text-fig. 1 it is represented by a firm black line. The proportion existing between the average measurement from the centre of the red line to the front edge of the shield and that from the centre of the red line to the hind edge is about 20 to 7.

It is a characteristic feature of the bud development of both *Cephalodiscus* and *Rhabdopleura* that the buccal shield differentiates very early; the rapid increase in the size of the shield in the early stages of development of the buds of *C. gilchristi* is even more striking than it is in the species *dodecalophus*. *nigrescens* and *hodgsoni*. In the earliest stages there is no posterior lobe; when it does appear (text-fig. 1, A) it is much narrower than the main portion of the shield. It is only during the very latest stages, when the bud is ripe and ready to become independent, that the width of the posterior lobe becomes approximately equal to that of the rest of the shield, as it is in the adult (text-fig. 1, F). The red line appears at about the stage when the first two pairs of plume-axes can be recognised (text-fig. 1, D). The lateral notch of the shield, due to a widening of the posterior lobe, does not become strongly marked until after the stage has been passed when four pairs of plume-axes are recognisable. In text-fig. 1, E, it will be noticed that the posterior flap is still comparatively narrow.

It is rather remarkable that the shields of very old buds, namely, those with five or six pairs of plumes, but with imperfectly-developed pinnules, are larger than the shields of adult polypides. A shield of such a stage would be intermediate in general characters between those shown in text-figs. 1, E and F, but would be larger than either. The explanation of this circumstance is probably that in the adult shield there is a greater development of muscular tissue present than in old buds, and that what appear to be fully expanded shields of adults are really less extended than are those of the old buds; by virtue of their greater muscularity the shields of the adults have become fixed by the killing and preserving fluids in a partially contracted state.

Around the front edge and sides of the main portion of the shield, extending as far back as the lateral notch, and not continued on to the posterior lobe or flap, is a broad dark margin (fig. 4, plate 2). The width and extent of this margin are indicated in text-fig. 1, F, by heavy dotting. The cells composing the dark rim are pigmented cells, similar to those so widely spread in the ectoderm of *C. nigrescens ;* they occur only in the marginal region of the dorsal surface of the shield (see text-fig. 3, *pg.*), and in fig. 4, plate 2, and text-fig. 1, F, are being viewed through the partially-transparent ventral wall of the shield. The cells when seen in bulk with the naked eye or with a low magnification appear blackish, but when examined with high powers of the microscope they are brown or yellow, in polypides which have been killed in formalin ; but in sections stained with Erlich's haematoxylin and eosin of polypides killed in osmic acid solution the pigmented cells are red, while in polypides killed in Flemming's fluid and in those killed in Perenyi's fluid the cells are colourless.

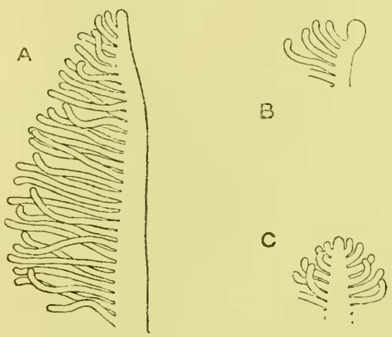
The pigmented cells stand high, and among them are colourless refractive beads (text-fig. 3, *r.b.*) similar to those first known in the end bulbs of the plumes of *C. dodecalophus*, but which investigation of *C. nigrescens* shows may occur on almost any part of the body. These I take to be the globules of the test material which have been accumulating in the cells, and coalescing, in the same manner as the globules of mucus in a goblet cell. On this assumption, the dorsal surface of the edge of the shield is in *C. gilchristi* the part of the body which is more particularly concerned with the secretion of the tubarium.

Plumes.—The plumes of *C. gilchristi* are six pairs in number. Occasionally only ten or eleven plumes can be found, but this may be due either to the accidental loss of one or more of the plumes, or, more usually, to one or both plumes of the sixth pair being retarded in their development. The plumes of *Cephalodiscus* develope successively, in pairs, and not simultaneously ; and the sixth pair, or one of the pair, may have failed to develope beyond an early stage at the time when the polypide was killed. Whether the plumes in question would have become larger had the polypide been allowed to live on is doubtful, because such a polypide is of full size, and possesses mature gonads. It is much more likely that the rudimentary plumes, sometimes no more than pinnule-less, club-shaped bodies situated near the bases of the plumes of the fifth pair, are permanently arrested.

The tip of the plume-axis is only in rare cases (text-fig. 2, B) swollen in a manner reminding one of the terminal bulbs of *C. dodecalophus* and *C. hodgsoni*. The axis in the great majority of instances terminates in the manner shown in text-fig. 2, A and C ; the tip is only slightly thicker than one of the pinnules, and it shows no transparent, highly refractive beads.

A moderately well-extended plume measures about ·9 mm. in length, a well-extended plume 1·1 mm. The maximum length observed was 1·5 mm. The pinnules are arranged in two rows along the axis, and there are from 25 to 30 in each row. Those near the tip are usually short, but not always as short as those shown in text-fig. 2. The longest pinnules occur at about one-third of the length of the plume-axis from the base, and these measure about ·4 mm. in length. The tips of the pinnules are very slightly enlarged, and are frequently found incurved.

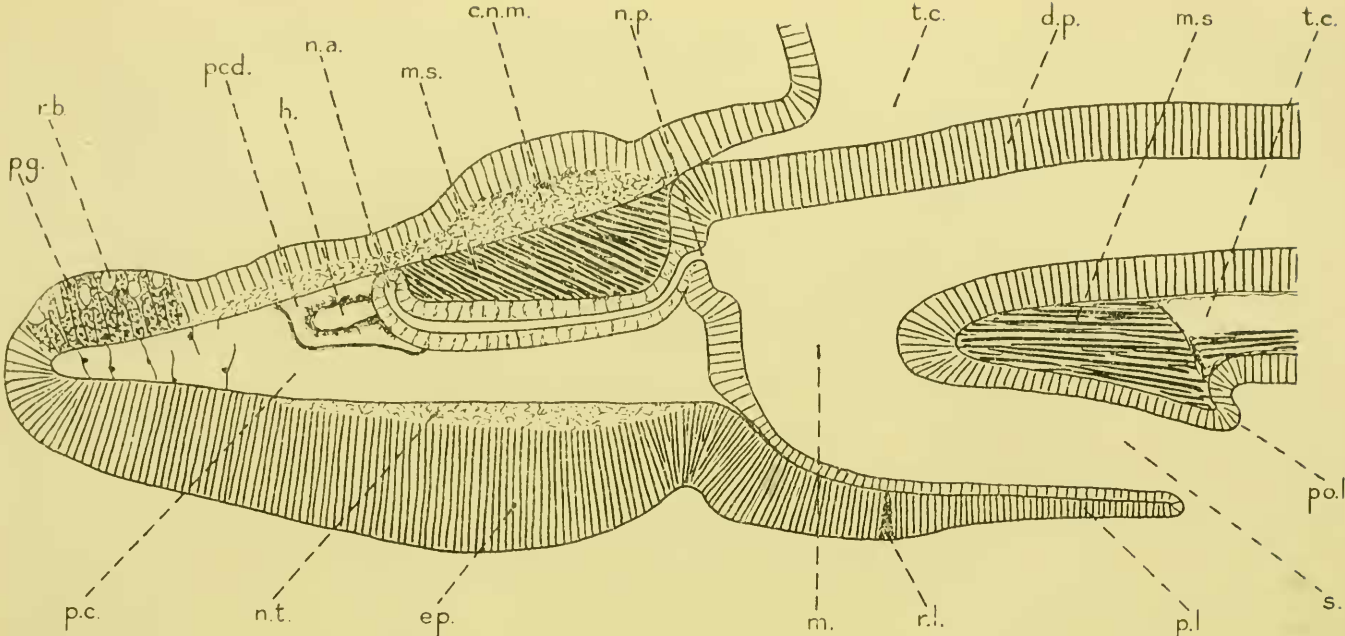
General Internal Anatomy.—The general internal anatomy of *Cephalodiscus dodecalophus* has been worked out in great detail by Harmer, Masterman, Schepotieff, and others,* and in the monograph on *Cephalodiscus* in the Report of the "Discovery" (Antarctic) Expedition I have given a series of diagrammatic sections of the body of *C. nigrescens*, taken through structures of particular interest, which with the ac-



TEXT-FIG. 2. A,—side view of a moderately expanded plume of *Cephalodiscus gilchristi* ; the pinnules of one side only are shown. B,—exceptional form of termination of the plume-axis ; cases of swollen terminations such as this are rare. C,—end portion of a normal plume seen from the aponeural aspect. (× 50.)

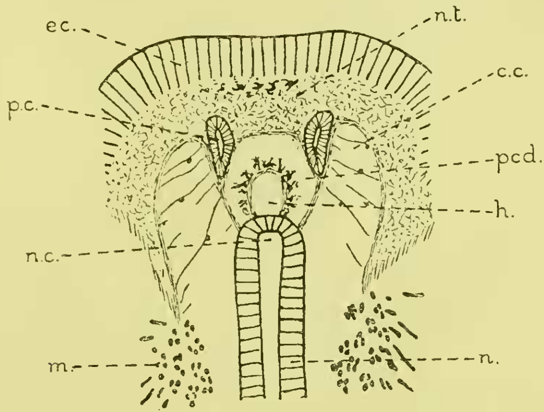
companying text afford a tolerably complete account of the anatomy of that species. As compared with these two species, the polypide of *C. gilchristi* does not present any striking peculiarities, and this being so, it does not call for a detailed description. The following have been recognised in sections of the polypides of *C. gilchristi*, and they so closely resemble their equivalents in the earlier investigated species of *Cephalodiscus* that they may be dismissed with a mere mention :—a pair of proboscis canals, a pair of collar canals, collar-canal muscle (cross-striped fibres), a pair of gill slits, pleurochords, post-oral lamella, divisions of the coelom, coelomic trabeculæ, muscles of the buccal shield, of the collar region, trunk region and stolon, and nerve tracts.

*A full bibliography is given in the Report of the "Discovery" Expedition.



Text-Fig. 3. Median longitudinal section of the antero-ventral part of a polypide of *Cephalodiscus gilchristi*. *c.n.m.*—central nerve mass; *e.p.*—tall, narrow epithelial cells of the face of the buccal shield; *d.p.*—dorsal wall of pharynx; *h.*—cavity of heart; *m.*—mouth; *m.s.*—muscle flanked septum separating the right and left collar cavities; *n.a.*—cavity of the anterior end of the notochord; *n.p.*—cavity of the posterior end of the notochord, where it opens into the pharynx; *n.t.*—nerve tract of the ventral walls of the buccal shield; *p.c.*—proboscis cavity, or cavity of the buccal shield; *pcd.*—pericardial cavity; *p.g.*—pigmented cells of the buccal shield; *p.l.*—posterior lobe of the buccal shield; *po.l.*—posterior edge of the post-oral lamella; *r.b.*—refractive bodies; *r.l.*—red line of the buccal shield; *s.*—space between the post-oral lamella and the posterior lobe of the buccal shield, leading into the mouth (*m*); *t.c.*—trunk cavity.

The notochord is interesting as being particularly long and bent. Several polypides were cut into serial sections, and in all of them the anterior and posterior ends of the notochord appeared more or less sharply bent (text-fig. 3, *n.a.* and *n.p.*). The cavity of the notochord is very distinct ; the thickness of the wall of the notochord is least in the basal parts. The apex of the notochord is in contact with the thin skeletal layer that lies immediately internal to the nerve tract of the dorsal surface of the buccal shield. Between the dorsal surface of the middle part of the notochord and the same sheet of skeletal connective tissue is a septum, which separates the right and left collar cavities, and is flanked on each side by a sheet of muscle, the fibres of which continue down the right and left sides of the mouth, and become nearly median again as they



TEXT-FIG. 4. Section of the pericardial region of the body of *Cephalodiscus gilchristi*, cut parallel to the face of the buccal shield. *c.c.*—anterior horn of collar cavity ; *cc.*—tall ectoderm cells of the dorsal wall of the buccal shield, cut obliquely ; *h.*—cavity of the heart ; *m.*—muscle fibres cut transversely and obliquely ; *n.*—wall of notochord ; *n.c.*—cavity of notochord ; *n.t.*—nerve tract ; *p.c.*—proboscis canal, cut transversely ; *pcd.*—pericardial cavity. In this diagram, and in text-fig. 3 an attempt has been made to place the pen-strokes in such positions and at such distances apart as shall give the general appearance and depth of tint of the several tissues as they appear in sections examined under the microscope ; the small areas enclosed by the pen-strokes are not intended to represent cells, except in a most diagrammatic manner.

attach themselves to the sides of the median septum between the right and left collar cavities in the region of the post-oral lamella (see the two tracts marked *m.s.* in text-fig. 3). The dorso-anterior wall of the pharynx touches the skeletal layer that lies immediately beneath the hinder part of the central nerve mass.

The heart is entirely in advance of the notochord, and in almost all cases is well dilated. The relations of the pericardium may be seen by reference to text-figs. 3 and 4, in which the pericardial cavity is marked *pcd*. Text-fig. 4 has been introduced into the present communication because it shows well the manner in which the anterior blind horns of the collar cavities (*c.c.*) project forward, and the position which the proboscis canals (*p.c.*) occupy between the pericardium and the anterior horns of the collar cavities. The part marked *n.c.* in this figure is not the true extremity of the notochord ; the tip of the notochord is bent dorsally as shown in text-fig. 3, and does not therefore come in the plane of the section represented in text-fig. 4.

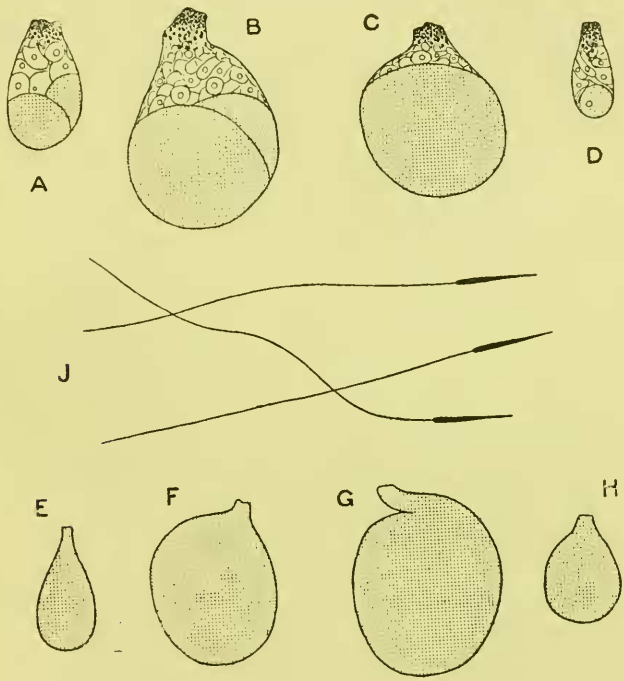
Gonads.—All the polypides of *C. gilchristi* that have been examined possess either two ovaries or two testes ; no hermaphrodite individuals like those of *C. nigrescens* and *C. hodgsoni*, possessing one ovary and one testis, were met with.

Ripe female polypides do not, as a rule, have two large ovaries : there is usually a large ovary and a comparatively small one. In text-fig. 5, A and B represent the two ovaries of one polypide drawn to the same scale of enlargement, and C and D represent the two ovaries of another polypide. If the female is immature, the two ovaries are of the same size. As in other species of *Cephalodiscus*, the ripe ova of *C. gilchristi* are large in comparison with the size of the ovary, and they are heavily charged with yolk. A ripe ovum is seen in text-fig. 5, C, and two in B. All ovaries, whether mature or not, have a short pigmented duct. The duct is shown uppermost in the figures A–D, and the pigmented cells are represented in these figures by black dots. In the polypides preserved in formalin the pigment is bright red, in others it is brownish, or even dark brown. In some cases, as in *C. hodgsoni* (" Discovery " Reports, pl. 5, figs. 44, 45), the red pigment is not confined to the duct, but occurs throughout the ovary.

The testes of the male have no red cells in their ducts. They vary in size according to the maturity of the individual, and the two testes of one polypide are usually equal in size. Examples of testes dissected out of four different polypides are shown in figures E–H of text-fig. 5. Figure G represents the largest testis found during the investigation. On teasing up some of the testes, and staining the contents, perfect spermetazoa may be seen. They have long, sharply-pointed heads, and long tails (text-fig. 5, J).

Free ova occur in the tubular spaces of the tubarium of specimen 10265 mixed up with the buds of the occupant polypides ; also in 13203 and 18655L. They are surrounded by a thin film of transparent material resembling that of the test, and this in some cases is produced into a sort of stalk which is confluent with the lining of the tubular cavity, and lends support to the suggestion that the envelope is not produced in any special way by the ovary or its duct, but originates from the same cells as secrete the tubarium. The usual size of the free ova is from ·4 by ·33 mm. to ·5 by ·4 mm.

As regards the distribution of the sexes, all the polypides of specimen 10265 that were examined proved to be females, and all those of 18551 were males ; but I have satisfied myself by careful examination of the polypides of specimens 13203, 18633



TEXT-FIG. 5. A. and B,—the two ovaries of one polypide of *C. gilchristi* ; C and D,—the two ovaries of another polypide ; E, F, G, H.—testes of different polypides ; J,—ripe spermatozoa. A—H are enlarged 50 diameters ; J, 500 diameters.

and 18655 that the same branch of the colony may have female polypides in some of the cavities and males in the others. The colony is thus monoecious. Why the specimens 10265 and 18551 are (apparently) unisexual is difficult to explain in the case of such sedentary animals as *Cephalodiscus* ; possibly the examination of a larger number of polypides from these specimens might result in the discovery of individuals differing in sex from the majority, but I was loth to sacrifice for such purpose much of the material entrusted to me, especially as in the other cases cited above I had found males and females in different cavities, not merely of the same colony, but of the same branch of the colony.

Summary.—The principal features of the new species now under consideration may be briefly stated as follows :—

Cephalodiscus (*Idiothecia*) *gilchristi*, n. sp. Material, from the Cape Seas at depths of 30 fathoms or more. Tubarium irregularly branched, some of the branches connected by solid cross bars ; distance from one branch to the next 30 mm. on an average, extremes 55 mm. and 17 mm. Width of terminal branches, not including spines, about 5 mm., width of basal stems about 10 mm. Ostia numerous, except in the main stems and attached base. The tubular cavities of the tubarium do not communicate with one another, and each is occupied by a single polypide and its buds, of which there may be from 2 to 5. Tubes 4 or 5 mm. long, 1 to 1.2 mm. across ; each tube with a single ostium, oval, 1 by 1.2 mm. across, sessile, or in the terminal branches with short, rarely long, peristomial tube. Spine-like processes of tubarium long and slender ; many of them can be traced for a considerable distance into the tubarium, each spine accompanying one of the tubes, more or less. Length of freely-projecting portion of the spine about 10 mm., width ·3 to ·4 mm. Occasionally an ostium has no spine directly related to it, or it has more spines than one. Polypides not black, but there is a broad dark margin to the buccal shield, not continued on to the posterior lobe. Distance from end of visceral mass to end of plumes about 1·8 mm. ; ditto to front of buccal shield about 1·5 mm. ; ditto to anus about 1 mm. Plumes six pairs ; tips of the plume-axes small, not globular, without clear, refractive beads. Stomach dilated ; anal aperture large. Stolon longer than the body. Polypides male and female ; alike except as regards the gonads, and may occur in different tubes of the same branch of the colony. Free ova found in the cavities of the tubarium measure from ·4 by ·33 mm. to ·5 by ·4 mm.

Short diagnoses of *Cephalodiscus sibogae, gracilis, hodgsoni, dodecalophus, nigrescens* and *levinseni*, similar to the above summary of characters of *Cephalodiscus gilchristi*, are given in my report on *Cephalodiscus* in the " Discovery " Expedition Reports, 1906, pp. 7-11.

The seven species of *Cephalodiscus*, of which descriptions have up to the present been published, may be quickly distinguished by the characters set out in the following table.

Key to the Identification of the Species of *Cephalodiscus*.

Polypides in a common cavity with numerous ostia (sub-genus *Demiothecia*),

Width of branches 2 mm. or less; colony diminutive; plumes less than six pairs.

Polypides black; plumes four pairs, except in males, which have one pair only, ... *sibogae* (Harmer, 1905).

Polypides with black pigment on stolon only; plumes five pairs,.......... *gracilis* (Harmer, 1905).

Width of branches 4 mm. or more; plumes six pairs,

Cavity of tubarium with smooth inner surface; distance from one branch to the next, about 10 mm......... *hodgsoni* (Ridewood, 1906).

Cavity of tubarium incompletely sub-divided by ridges and partitions of irregular shape; distance from one branch to the next, about 22 mm....... *dodecalophus* (M'Intosh, 1882).

Polypides in separate cavities, each with a single ostium (subgenus *Idiothecia*),

Polypides black; plumes seven pairs,

Colony massive, width of branch 15 to 25 mm. or more; peristomial tubes very short, each with a short blunt lip; no spines, ... *nigrescens* (Lankester, 1905).

Polypides not black; plumes six pairs,

Width of branch (including peristomes) about 12 mm.; peristomial tubes longer than their width, each with a short lip; no spines, ... *levinseni* (Harmer, 1905).

Width of branch 5 to 10 mm.; peristomial tubes short or absent; spines long and slender, simple or forked,........ *gilchristi* (new species).

EXPLANATION OF THE PLATES.

Plate 1.

Photographic reproduction of a colony of *Cephalodiscus* (*Idiothecia*) *gilchristi*; natural size. Specimen No. 18551.

Plate 2.

Fig. 1. A branch of the tubarium of *Cephalodiscus gilchristi*, enlarged 2½ diameters. Specimen No. 13203.

Fig. 2. Longitudinal section of a branch of *C. gilchristi*, enlarged 2½ diameters. The darkest parts are tubes seen in section; the paler tubes are not cut into, but are seen through the transparent test.

Fig. 3. Transverse section of a branch of *C. gilchristi*, enlarged 2½ diameters.

Fig. 4. Polypide of *C. gilchristi*, ventral view, enlarged about 45 diameters. *b.* and *b.*, buds; *b.s.*, dark edge of the buccal shield; *ga.*, bulging of the side of the body caused by the stomach; *go.*, bulging of the side of the body caused by the gonad; *pl.*, plumes; *p.s.*, posterior lobe of the buccal shield; *r.l.*, red line of the buccal shield; *st.*, stolon.

Figs. 5 and 6. Two buds, of about the same age, showing the extremes of the positions in which the posterior lobe of the buccal shield may be found. *a.* and *p.*, anterior and posterior lobes of the buccal shield; *b.*, " body " of the bud; *s.*, stalk.

(Figs. 1–3 were drawn by Miss G. M. Woodward.)

Plate 3.

Fig. 7. End view of a branch of *C. gilchristi* showing the relation of spines to ostia. Enlarged 4½ diameters. At *a* and at *b* there is one spine between two ostia; each of the other six ostia has a spine of its own.

Fig. 8. Transverse section of one of the solid cross-bars that connect up the branches of the tubarium. Enlarged 6 diameters. *a*, *b*, *c*, *d*, sections of spines buried in the common test.

Figs. 9, 10 and 11. Terminal portions of branches, to show the relation of the spines to the tubes. The spines are all represented as cut short. The irregular line in the lower part of figs. 9 and 10 marks where the piece of tubarium figured was torn away from the rest of the branch. In fig. 11 the torn surface, bounded by the line *k*, is directed obliquely towards the observer. The figures are enlarged 8 or 9 diameters. For explanation of the letters see text.